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Influence of Ca Concentration on Growth, Tissue Concentration, and Nutrient Uptake of *In Vitro* Propagated Plums and Lovell Seedlings

Key Words: *Prunus persica*, *Prunus domestica*, *Prunus institia*, nutrient uptake rates, relative growth rate.

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ABSTRACT

Seedlings of 'Lovell' peach [*Prunus persica* (L.) Batsch], and *in vitro* propagated plums, 'St. Julien A GF 655-2' [*Prunus institia* (L.) Bullace] (655-2), 'Damas GF 1869' [*Prunus domestica* (L.)] (D1869), and 'Clark Hill Red Leaf' [*Prunus saliciana* (Lindl) x *Prunus cerasifera* (EHRH)] (CH redleaf) were grown in the greenhouse 45 or 51 days in nutrient solutions containing 2, 6, 22, 200, and 400 µM Ca. Terminal length, number of laterals, trunk cross-sectional area, and root volume were increased by the 22 µM Ca treatments at harvest 1. The CH redleaf and 655-2 plums had the largest increase in growth for

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harvest 1, but the 'Lovell' peach seedlings and D1869 plum had the largest increase in growth for harvest 2. There were no leaf symptoms of Ca deficiency when the leaf Ca concentration in the tissue exceeded 2500 µg/g (dry wt.) Calcium concentration was increased from 1406 to 4109 µg/g (dry wt.) in the stems, and from 540 to 2633 µg/g (dry wt) in the roots by Ca treatments of 400 µM after 45 days of growth. Calcium uptake rate for 'Lovell' seedlings was greater than were rates for CH redleaf and 655-2 plums at all solution concentrations during the first 45 days of growth. The Ca uptake rate for D1869 plum was greater than the rate for 'Lovell' seedlings during the second growth period. An interaction between Ca concentration and plant species occurred for P, K, and Mg uptake rates at both harvest dates. The in vitro propagated D1869 plum was equal to the 'Lovell' seedlings in growth, tissue Ca concentration, and Ca uptake rates.

INTRODUCTION

The influence of peach rootstocks on peach scion longevity[1,2], growth, and yield[1,2] and nutrient content[4,5] has been reported. In the Southeast, the preferred rootstock is 'Lovell'[6,7]. Scions on certain root-knot-nematode-resistant rootstocks do not survive as long on old peach land as 'Lovell' rootstock[1]. Calcium nutrition may play a role in the Peachtree Short Life Syndrome (PTSL). 'Lovell' and 'Halford' seedlings appear to be more efficient in calcium uptake at low pH[8,9] than are rootstocks with higher mortality rates on PTSL sites[1,5,10]. When 'St. Julien A' was used as a rootstock for 'Italian Prune' [Prunus domestica (L.)], 'St. Julien A' was more efficient in the uptake of Ca than were 'Lovell' seedlings[4]. Other studies[11,12] have shown that peach scions on plum rootstock are more successful than peach on peach rootstock in poorly drained soils.

Two plums, Prunus domestica and Prunus institia are important peach rootstocks that are commercially propagated in vitro in Europe[13]. Thus, if these two plum cultivars have calcium uptake efficiency comparable to 'Lovell' seedlings, they may have potential as rootstock for peach scions on PTSL sites in the Southeast. The objectives of this study were to characterize nutrient uptake rates and efficiency, growth rates, and tissue nutrient concentration of three in vitro propagated plums using 'Lovell' seedlings as standard for comparison.

MATERIALS AND METHODS

'Lovell' peach seeds were germinated and seedlings were grown for 48 days in sand in the greenhouse to a height of 20 to 32 cm. During the 48 days, they were fertilized once with Peter's[14] 25-20-20 (25N-8.7P-16.6K) fertilizer.

CH redleaf, 655-2, and D1869 plants were propagated in vitro. Following propagation, the plants were transferred to a 1:1:1 peat, vermiculite, soil medium and acclimated under mist in the greenhouse. The plum plants were fertilized weekly for 4 weeks with Peter's[14] fertilizer solution, and then once every 2 weeks until the plums were transferred to the nutrient solution. Total growing time in the greenhouse for CH redleaf plums was 85 days, and 58 days for 655-2 and D1869 plums. This difference in age was necessitated by facility limitations, and not by any inherent rootstock characteristics.

'Lovell' seedlings and the three plum selections were removed from the greenhouse medium, the roots were washed in distilled water for 2 hours and were transferred into 15-liter tanks. Each tank contained 1 'Lovell' seedling and 1 of each plum selection. Nutrient concentrations were as follows: 0.25 mM KH_2PO_4, 0.5 mM KCl, 0.25 mM NH_4Cl, 0.25 mM KNO_3, 0.25 mM $MgSO_4$, 75 µM Fe DTPA, 46 µM B, 9 µM Mn, 0.8 µM Zn 0.3 µM Cu, and 0.05 µM Mo.

When 'Lovell' seedlings and plum plants were moved to nutrient solution, Ca concentrations of 2, 6, 22, 66, 200, and

400 µm were initiated by adding $CaCO_3$ to the nutrient solution. Temperature was maintained at 24° ± 5°C, and sunlight was supplemented with fluorescent light to produce a minimum of 250-300 µE m^{-2} s^{-1} at the canopy for a 16-hr day.

Solution pH was measured daily and adjusted to pH 5.5 when needed with 0.1N HCl or NaOH. To minimize the fluctuation in pH, an organic buffer, the sodium salt of 2-(N-morpholino) ethanesulfonic acid (pH 6.15) was added to the nutrient solution. Nutrient concentration was monitored by determining the nutrient concentration in each tank every 2 days, and adjustments were made to prevent depletion of Ca or imbalances between the other nutrients. The solution volume was maintained in the tank by adding nutrient solution. The vigorously-aerated nutrient solutions were changed every 7 days. During this period, the concentration of nutrients did not vary more than 5% from the original concentration.

Uniform 'Lovell' seedlings and plum plants were selected for the experiment and representative samples were harvested, weighed, and chemically analyzed to serve as a comparative beginning for treatment effects. Seedlings and plums in the 2 and 6 µM Ca treatments were harvested at the first harvest date (45 days after initiating Ca treatments), and the remaining seedlings and plums were pruned to obtain leaf, stem, and root tissues for chemical analysis and dry weights; root volumes, lateral stem number, trunk cross-sectional area and terminal length were measured. These plants were then grown and harvested (H-2) 51 days later (96 days after initiating Ca treatments) and measurements of the new growth recorded. Plants were separated into leaves, stems, and roots, were freeze-dried and ground to pass a 40-mesh screen. Concentrations of Ca, Mg, and K were determined by atomic absorption spectrophotometry. The P concentration was determined on ashed tissue by the ascorbic acid method of Murphy and Riley[15]. Nutrient uptake rates for H-1 were

calculated from the change in total elemental content and root fresh weights of harvested tissue from that of the representative plants used as reference samples. Uptake rates for H-2 were calculated from the total elemental content of tissue produced after H-1 and the change in root fresh weight from H-1 and H-2. Root fresh weight at H-1 (after pruning) was calculated from the ratio of fresh weight:root volume derived from pruned root samples. Root volumes were determined using a water-displacement method. Nutrient uptake rates were calculated according to the equation of Loneragen, Snowball, and Simmons[16]. The equation was:

$$I_m = \frac{M_2 - M_1}{WR_2 - WR_1} \cdot \ln \frac{WR_2/WR_1}{t_2 - t_1}$$

where I_m is the uptake per g fresh weight of root, M is total elemental content in the peach seedlings (leaves + stems + roots), WR is root weight, and t is time. Subscripts 1 and 2 denote initial and final harvests.

The experimental design was a factorial arrangement of 4 plant species x 6 Ca concentrations in a randomized complete block of 5 replications for H-1 and 4 plant species x 4 Ca concentrations for H-2.

RESULTS AND DISCUSSION

Ca deficiency symptoms for 'Lovell' peach seedlings have been reported for various Ca concentrations and nutrient solutions pH[8,9]. The Ca deficiency symptoms that are described here relate only to our determination of the threshold Ca concentration in nutrient solution for Ca deficiency symptoms for plum plants. 'Lovell' seedlings are included as a standard comparison.

Initial Growth

Due to the difference in time of growth for the *in vitro* propagated plum and Lovell seedling, prior to initiation of Ca treatment representative samples were harvested to measure ini-

tial growth (Table 1) and Ca, K, P, and Mg concentrations in the leaves, stems and roots (Table 2). The growth measurements were used as a baseline, and all data presented are the increases for the two harvest dates. The concentration of nutrients is presented to establish to establish the bases for calculation of nutrient uptake rates and to follow the change in nutrient concentration during the experimental periods.

Shoot deficiency symptoms.

Ca deficiency symptoms developed in the 2 µM Ca treatments with 'Lovell' seedlings, and 655-2 and D1869 plums 18 days after treatment initiation, and were observed in all plants in the 2 and 6 µM Ca treatments 2 days later. During the 45 days of Ca treatments, Ca deficiency symptoms advanced to the beginning stages of marginal chlorosis in the 'Lovell' seedlings and plums in the 6 µM Ca treatments, and to the expanding chlorosis stage in the 2 µM Ca treatments. Following 67 days of Ca treatments, Ca deficiency symptoms were observed in the 655-2 plum growing in the 22 µM Ca treatment. None of the other plants growing in the 22 µM Ca treatment exhibited Ca deficiency symptoms during the remainder of the experiment.

Growth.

The 22, 66, 200, and 400 µM Ca treatments increased terminal length and root volume over the 2 and 6 µM Ca treatments (Table 3). The greatest increase in lateral number occurred at the 66 µM Ca treatment. Generally, Ca concentrations of 22, 66, 200, and 400 µM increased trunk cross-sectional area over the 2µM Ca treatment. Ca treatments of 6 µM or more increased dry weight of leaf and stem tissue over the 2 µM Ca treatment.The maximum increase in root dry weight occurred at 6 µM Ca. The increase in root dry matter was lower in Ca treatments of 22 µM or greater.

During the first 45 days of the experiment, the increases in terminal length and trunk area were generally greater for plum plants than for 'Lovell' seedlings (Table 4). The 655-2 plums

TABLE 1.

Initial Growth Measurement for *In Vitro* propagated Plums and Lovell Seedlings.

Cultivar	Plant[z] height	X[z] area	Fresh weight leaves	Fresh weight stems	Fresh weight roots	Dry weight leaves	Dry weight stems	Dry weight roots
	(cm)	(mm^2)	(g/plant)			(mg/plant)		
Lovell	21.4	4.29	1.15	0.73	0.66	248	152	68
CH Redleaf	38.7	5.94	5.44	3.73	3.04	1500	1250	550
D-1869	19.2	4.24	3.51	1.02	1.72	740	340	250
655-2	21.6	5.90	2.28	0.47	0.74	400	110	100

[z]Means of 30 seedlings of each cultivar.

[y]Means of 10 seedlings of each cultivar.

had the smallest increase in lateral number, while the other plums had increases in lateral number comparable to 'Lovell' seedlings. The increase in root volume for plums was equal to or greater than the increase in root volume of 'Lovell' seedlings. This same trend occurred for leaf, stem, and root tissue dry weights.

For H-2, only the growth parameters of D1869 plum were consistently equal to or greater than 'Lovell' seedlings. The increase in root volume and dry weight of CH redleaf was, however, also greater than the increase in root volume and dry weight of 'Lovell.' Only the growth of D1869 was greater than 'Lovell" during the 96 days of the experiment.

The small increase in terminal length and lateral number (Table 4) for the 655-2 at both harvests occurred because the 655-2 plum required a Ca concentration of between 22 and 66 µM in nutrient solution to prevent reduced growth due to Ca deficiency. The small increase in terminal length and lateral number for CH redleaf for H-2 was the result of reduced secondary bud break

TABLE 2.

Initial Nutrient Concentration for *In Vitro* Propagated Plums and Lovell Seedlings.

Cultivar	Nutrient	Nutrient concentration[z] leaves	stems	roots
		µg/g (dry weight)		
Lovell	Ca	7,500	4,313	2,831
	K	25,688	15,125	16,072
	P	4,375	5,625	4,931
	Mg	4,938	3,438	3,470
CH Redleaf	Ca	15,938	11,813	6,125
	K	25,063	8,938	27,813
	P	2,750	1,875	4,000
	Mg	3,813	1,313	3,500
D-1869	Ca	20,125	18,313	5,332
	K	31,438	9,500	22,727
	P	3,625	1,750	3,147
	Mg	4,750	2,125	2,535
655-2	Ca	10,083	19,313	5,625
	K	19,441	41,875	15,375
	P	2,743	5,625	3,000
	Mg	2,178	5,813	2,250

[z]Mean concentration of nutrient determinations of 10 plants of each cultivar.

after H-1. None of the other plants exhibited Ca deficiency symptoms after H-1.

Tissue Ca concentration.

The leaf Ca concentration after 45 days was lower than the initial concentration in all plants in treatments containing 2, 6, 22 and 66 µM Ca treatments, but with 200 and 400 µM Ca treat-

TABLE 3

The Influence of Calcium Concentration in Nutrient Solution on Growth of 'Lovell' and *In Vitro* Propagated Plums.

Ca Concn (uM)	Increase terminal length (cm)	lateral (No.)	trunk area (mm)2	root vol (cc)	dry wt (g/plant) leaves	stems	root
	Harvest 1 (45 days)[z]						
2	16.4	0.3	3.2	5.9	1.5	0.9	0.6
6	27.9	1.0	5.3	7.7	2.1	1.3	0.9
22	43.7	3.5	6.6	14.9	2.3	1.0	0.4
66	44.2	5.7	6.3	14.8	2.8	1.4	0.4
200	50.0	3.8	6.8	12.9	2.3	1.3	0.4
400	43.7	3.4	6.4	12.9	2.3	1.1	0.3
FPLSD 5%[y]	12.37	3.00	3.28	5.71	0.52	0.40	0.17

[z]Days after initiation of Ca treatments.

[y]Fishers' Protected LSD.

ments Ca concentration after 45 days was equal to the initial Ca concentration (Fig. 1). The 22 µM Ca treatment appeared to be the Ca concentration in solution where growth of all plants exceeded the Ca uptake and, consequently, lowered Ca concentration in the leaves. The change in leaf Ca concentration with increasing nutrient solution Ca was much greater for the D1869 plum than the 655-2, CH redleaf plums and 'Lovell' seedlings.

The stem Ca concentration for the 'Lovell' seedlings and the plum plants followed similar patterns of change as leaf Ca con-

TABLE 4.

The Influence of 'Lovell' Peach Seedlings and In Vitro Propagated Plums on Growth and Dry Weight Increase in Nutrient Solution.

	Increase						
	terminal length	lateral	trunk area	root vol	dry wt (g/plant)		
Cultivars	(cm)	(No.)	(mm)2	(cc)	leaves	stems	root
			Harvest 1 (45 days)[z]				
Lovell	26.8	3.6	4.8	9.0	1.8	0.6	0.3
CH redleaf	48.0	2.9	5.1	17.0	3.5	2.0	0.9
D1869	32.1	4.8	5.7	11.0	2.2	0.9	0.4
655-2	45.7	0.3	7.6	9.3	1.7	1.1	0.4
FPLSD 5%[y]	5.05	1.23	0.41	2.33	0.42	0.32	0.14
			Harvest 2 (96 days)[z]				
Lovell	135.5	8.4	---[x]	14.5	3.9	1.3	2.2
CH redleaf	85.0	2.5	---	21.6	3.3	1.4	2.7
D 1869	214.1	20.1	---	21.5	6.0	2.2	2.4
655-2	63.3	1.9	---	15.2	1.9	1.0	1.2
FPLSD 5%	26.47	2.60		3.79	0.96	0.23	0.28

[z]Days after initiation of Ca treatments.

[y]Fisher's Protected LSD

[x]Data not recorded for harvest 2.

centration for harvest 1 (Fig. 1). The change in the stem Ca concentration for the D1869 plum and 'Lovell' seedlings was similar, while stem Ca concentrations in the CH redleaf and 655-2 plums were much less. However, there was no difference in root Ca concentration between 'Lovell' seedlings and plum plants, thus only the influence of Ca treatments is presented.

The leaf Ca concentration of 'Lovell' seedlings and the plums exceeded the initial Ca concentration at harvest 2 at the 200 and 400 µM Ca treatments (Fig. 2). The stem Ca con-

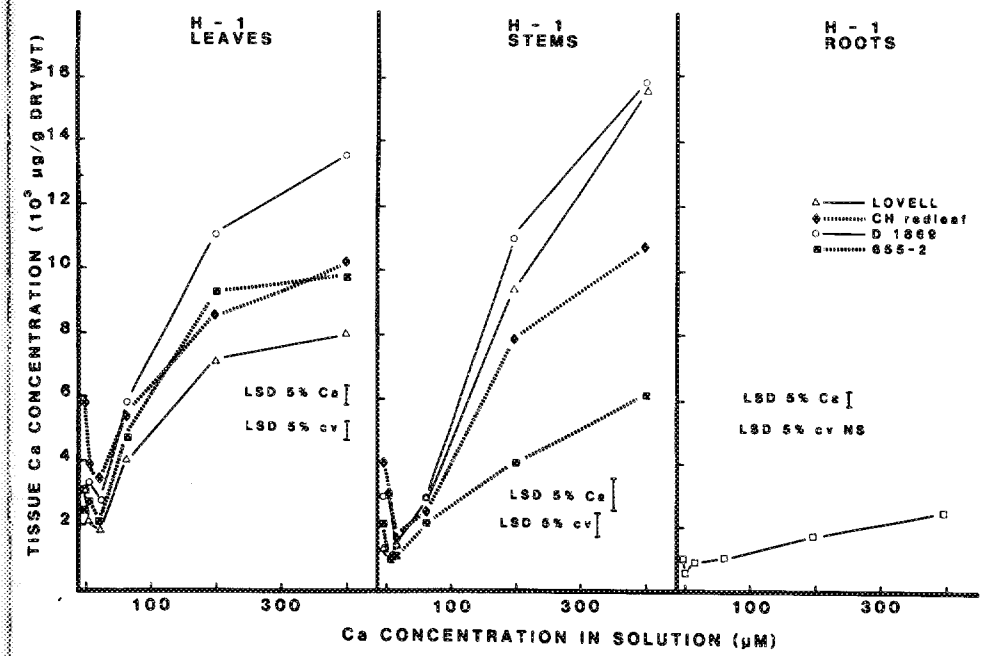

Figure 1. Influence of calcium concentration in nutrient solutions on calcium concentration in leaves, stems, and roots of 'Lovell' seedlings and in vitro propagated plums after 45 days of growth.

centration in the 'Lovell' seedlings was increased 40 to 50% more than the plum stems in the 200 and 400 µM Ca treatments. Thus, it would appear that 'Lovell' seedlings accumulated Ca in the stems rather than in the roots or leaves, while D1869 plum plants accumulated Ca in the leaves rather than in stems or roots. The accumulation of Ca in the leaves of the D1869 plum plants may be a disadvantage because a larger percent of the total Ca in the D1869 will be lost when leaves are lost in the fall. The 655-2 plum appears to be very inefficient in accumulating Ca in any of the plant organs for either harvest.

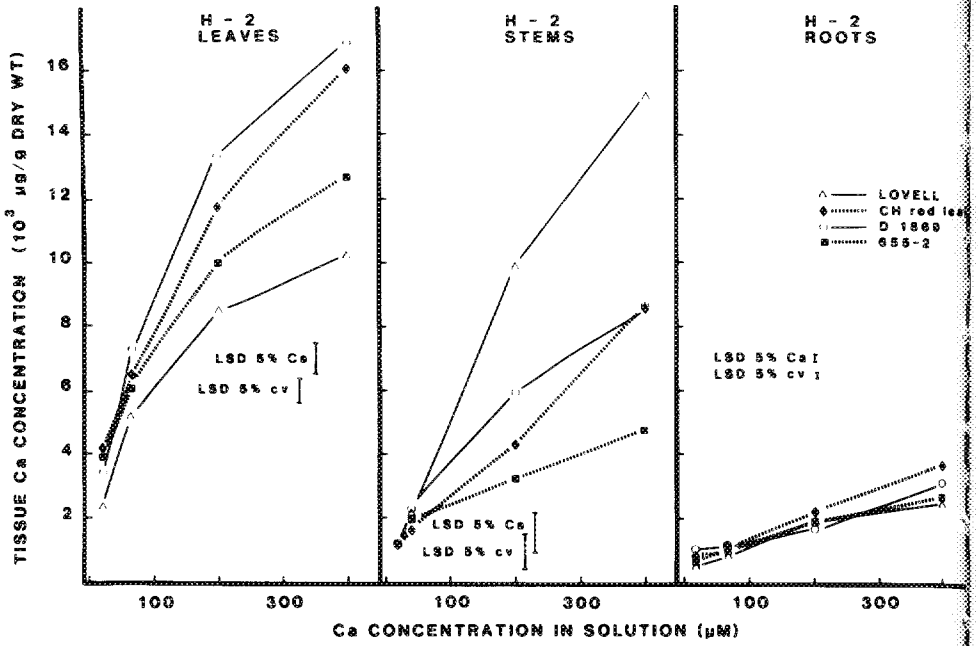

Figure 2. Influence of calcium concentration in nutrient solutions on calcium concentration in leaves, stems, and roots of 'Lovell' seedlings and in vitro propagated plus after 54 days of growth.

Ca uptake rates.

The Ca uptake rates for 'Lovell' seedlings and plum plants increased as Ca levels increased for H-1 (Fig. 3). The Ca uptake rate for the 655-2 plum increased most dramatically from the 6 to the 200 µM Ca treatment, but decreased at the 400 µM Ca treatment. The Ca uptake rate was similar for 'Lovell' and the D1869 plum from the 6 to 200 µM Ca treatments, but the Ca uptake rate was much greater for 'Lovell' seedlings at the 400 µM Ca treatment for H-1. The CH redleaf plum was very inefficient in Ca uptake at all Ca treatments in H-1.

'Lovell' seedlings and D1869 plum had linear Ca uptake rates over the Ca concentrations studied for H-2; however, the Ca

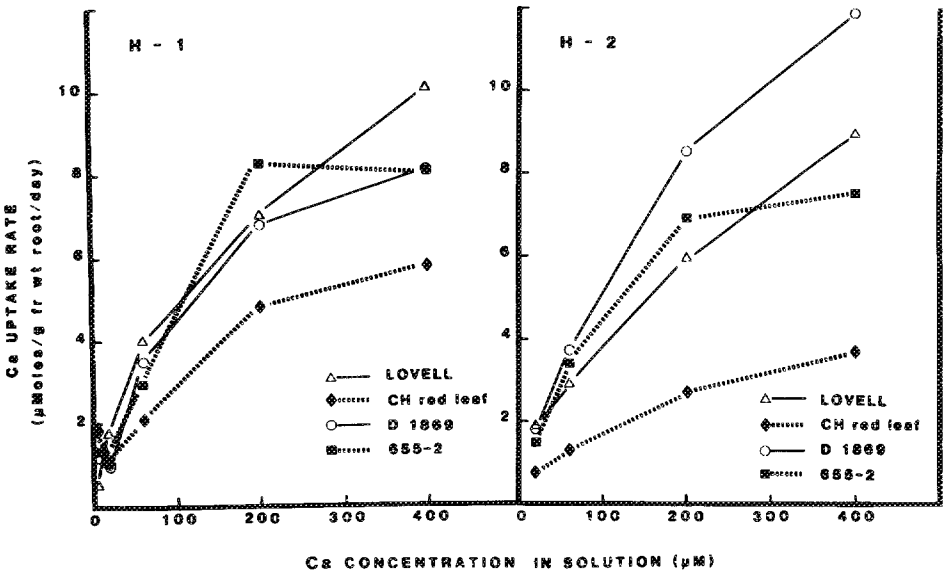

Figure 3. Influence of calcium concentration in nutrient solution on calcium uptake rates for 'Lovell' seedlings and in vitro propagated plums after 45 and 51 days.

uptake rate was higher for the D1869 plum (Fig. 3). The Ca uptake for the 655-2 plum reached a maximum at the 200 µM Ca treatment. The Ca uptake rate for the CH redleaf was the lowest for all cultivars studied at both harvests. Growth of the CH redleaf plum was reduced for H-2 (Table 4). The combination of reduced growth and Ca uptake of the CH redleaf plum would probably limit its usefulness as a potential rootstock on PTSL sites when compared to 'Lovell' seedlings.

The uptake rates of K, P, and Mg were significantly increased by Ca treatments of 2, 6, and 22 µM, and plant species for H-1 (Table 5). The only exception was the D1869 plum; a maximum uptake rate for K, P, and Mg occurred at the 66 µM Ca treatment and decreased at the 200 and 400 µM Ca treatments. The P and Mg uptake rates of D1869 and CH redleaf plums were less

TABLE 5.

The Influence of Ca Concentration on K, P, and Mg Uptake Rates of 'Lovell' Seedlings and In Vitro Propagated Plums Grown for 45 Days (H-1, 45)z.

	Nutrient																					
	K						P						Mg									
	Ca concentration (µM)						Ca concentration (µM)						Ca concentration (µM)									
Cultivar	2	6	22	66	200	400	means	2	6	22	66	200	400	means	2	6	22	66	200	400	means	
	µM/g fr wt root/day							µM/g fr wt root/day							µM/g fr wt root/day							
Lovell	11.2	14.0	34.9	35.7	32.0	36.2	27.3	3.3	3.9	5.4	5.2	4.8	6.2	4.8	4.7	5.8	9.7	8.7	6.5	6.5	7.0	
CH redleaf	6.0	7.5	10.8	11.5	12.8	11.3	10.0	1.9	1.9	2.2	2.2	2.3	2.0	2.1	3.6	3.9	4.6	3.9	3.5	2.7	3.7	
D1869	8.9	12.3	19.1	24.1	20.2	17.9	17.1	1.7	2.1	2.5	3.5	2.9	2.6	2.6	3.4	4.3	5.8	6.9	4.9	3.8	4.9	
655-2	13.5	21.9	27.5	28.0	36.1	27.6	25.8	2.7	4.0	3.9	4.3	6.6	5.1	4.4	3.7	5.2	6.2	6.2	7.1	5.1	5.6	
Means	9.9	13.9	23.1	24.8	25.3	23.3		2.4	3.0	3.5	3.8	4.2	4.0		3.9	4.8	6.6	6.4	5.5	4.5		
Cultivar FLSD.05y= 3.13								Cultivar FLSD.05 = 0.59							Cultivar FLSD.05 = 0.65							
Ca concn FLSD.05 = 3.84								Ca concn FLSD.05 = 0.72							Ca concn FLSD.05 = 0.80							
Cv x Ca FLSD.05 = 5.43								Cv x Ca FLSD.05 = 1.02							Cv x Ca FLSD.05 = 1.14							

z Day after initiation of Ca treatments

y Fisher's Protected LSD; Cultivar means (Columns); Calcium means (rows).

than the uptake rates of 'Lovell' seedlings. The K uptake rate for the 655-2 plums was equal to or greater than the uptake rate for 'Lovell' seedlings at the 2 and 6 µM Ca treatments.

The uptake rates of K, P, and Mg for H-2 were lower than the uptake rates observed during H-1 (Table 6). The K uptake rate for the 655-2 plum was increased by Ca treatments 2, 6, 66, and 200 µM Ca. However, there was little change in K uptake rate at the 400 µM Ca treatment. The K uptake for the CH redleaf plum was only 20% of the K uptake of 'Lovell' seedlings. The P uptake was increased for 'Lovell' seedlings and plum plants for H-2. A reason for the increase in P uptake for harvest 2 was that a larger demand was created as a result of pruning the plants, which resulted in more actual meristematic areas as buds broke and grew actively.

Results of this experiment show that two in vitro propagated plums have tissue Ca concentrations and Ca uptake rates comparable to those of 'Lovell' peach seedlings at Ca concentration ranges of 20 to 200 µM. The D1869 plum was more efficient in Ca uptake than the other plums.

Calcium deficiency symptoms were observed in leaves of peach seedlings and plums in the 2, 6, and 22 µM Ca treatments for H-1, and were exhibited in leaves in the 655-2 plum in the 66 µM Ca treatment for H-2. The Ca concentration in the tissue ranged from 1850 to 3400 µg/g (dry weight) for all plants for H-1, and 2400 to 4100 µg/g (dry weight) for H-2. It appears that the Ca concentrations of about 2300 µg/g (dry weight) for 'Lovell' seedling leaves, 3500 µg/g (dry weight) for the D1869 and CH redleaf plum leaves, and 4000 µg/g (dry weight) for the 655-2 plum are about the marginal level for Ca deficiency symptoms to develop. The leaf Ca concentration of 2300 to 4000 µg/g (dry weight) appears to be threshold where Ca deficiency was observed. The leaf Ca concentration range of 3400 to 6000 µg/g (dry weight) appears to be the range where growth was affected but no defi-

TABLE 6.

The Influence of Ca Concentration on K, P, and Mg Uptake Rates of 'Lovell' Seedlings and In Vitro Propagated Plums Grown for 51 days (H-2, 96)[z].

	Nutrient														
	K					P					Mg				
	Ca concentration (uM)					Ca concentration (uM)					Ca concentration (uM)				
Cultivar	22	66	200	400	means	22	66	200	400	means	22	66	200	400	means
	uM/g fr wt root/day					uM/g fr wt root/day					uM/g fr wt root/day				
Lovell	27.2	19.7	22.4	26.1	23.9	5.0	4.2	4.7	5.7	4.9	8.7	5.9	4.9	4.7	6.1
CH redleaf	5.3	5.3	5.7	6.8	5.8	1.5	1.4	1.8	1.7	1.6	2.6	2.3	1.9	1.5	2.1
D1869	21.4	18.7	23.6	23.9	21.9	3.1	2.8	3.6	3.6	3.3	6.7	5.9	5.8	5.4	5.9
655-2	16.9	23.6	28.2	23.2	23.0	3.4	4.3	5.4	4.5	4.4	3.9	5.2	4.7	3.6	4.4
Mean	17.7	16.8	19.9	20.0		3.2	3.2	3.9	3.9		5.5	4.8	4.3	3.8	
	Cultivar $FLSD_{.05}$[y] = 2.31					Cultivar $FLSD_{.05}$ = 0.36					Cultivar $FLSD_{.05}$ = 0.56				
	Ca concn $FLSD_{.05}$ = 2.83					Ca concn $FLSD_{.05}$ = 0.45					Ca concn $FLSD_{.05}$ = 0.68				
	Cv x Ca $FLSD_{.05}$ = 3.99					Cv x Ca $FLSD_{.05}$ = 0.63					Cv x Ca $FLSD_{.05}$ = 0.96				

[z] Day after initiation of Ca treatments

[y] Fisher's Protected LSD; Cultivar means (Columns); Calcium means (rows).

ciency symptoms were observed. The Ca concentrations in nutrient solution of 22 to 66 µM Ca concentration appear to be in the marginal range for supplying adequate Ca to eliminate deficiency symptoms.

The D1869 plum had growth, tissue Ca concentration, and Ca uptake rates equal to or greater than 'Lovell' peach seedlings. The CH redleaf and 655-2 plums were inefficient in growth, tissue Ca concentration, and Ca uptake compared to 'Lovell' seedlings. It would appear that the D1869 should be considered as a potential rootstock for peaches because it can easily be produced using tissue culture techniques to supply the peach industry with a source of homozygous rootstock.

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EFFECT OF FE LEVEL AND SOLUTION CULTURE PH ON SEVERITY OF CHLOROSIS AND ELEMENTAL CONTENT OF APPLE SEEDLINGS

KEYWORDS: Malus domestica, roots

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ABSTRACT: The development of chlorosis and subsequent growth of apple seedlings grown in solution cultures containing various levels of Fe under a range of solution pH regimes were examined. Initial solution pHs were 5.5, 6.5 and 7.8 respectively, with Fe levels of 0.0, 0.13 and 1.3 ppm in a 3x3 factorial arrangement. Leaf chlorosis increased with a decrease in Fe levels and with higher solution pH. Nutrient solutions were changed weekly and during each weekly cycle solution pH levels were monitored. Independent of Fe level, the lower the initial solution pH the greater the change in solution pH during each weekly cycle. Decreasing solution Fe levels decreased both leaf and root Fe concentrations but both parameters were relatively unaffected by solution pH suggesting a solution pH by Fe supply interaction at the root surface.

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